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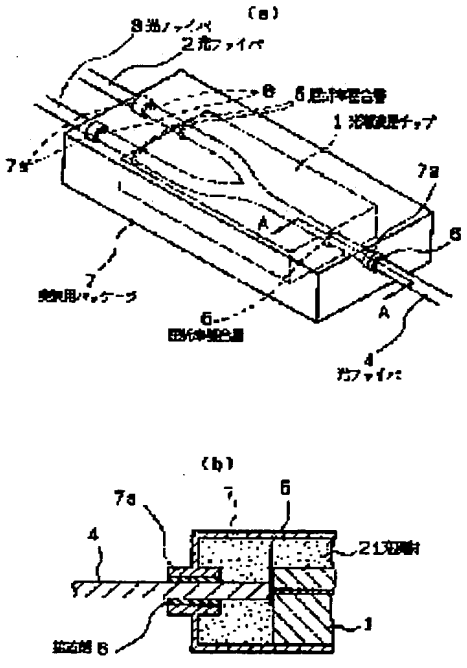
(54) OPTICAL WAVEGUIDE CIRCUIT MODULE



(57)Abstract:

PURPOSE: To prevent characteristic deterioration caused by mismatching in coefficient of linear expansion between optical waveguide circuit constituent members.

CONSTITUTION: An optically transparent filler 21 which has a refractive index nearly equal to the refractive index of a refractive index matching layer 5 provided on the connection border surface between an optical waveguide chip 1 and optical fibers 2, 3, and 4 for optical input and output and also has viscosity is charged in the periphery of the border surface and this filler enters a gap if the gap is formed between the optical fiber end surfaces and

optical waveguide chip owing to peeling, thereby holding characteristics similar to those of the optical waveguide before the connection border surface peeling.

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2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The optical waveguide circuit module characterized by the thing which are equipped with an optical-waveguide chip and the optical fiber for optical I/O

connected so that the optical axis may be in agreement with this optical-waveguide chip, and has a refractive index almost equivalent to the refractive index of the aforementioned index-matching layer for the circumference of the aforementioned connection interface at least in the optical waveguide circuit module which has an index-matching layer in the connection interface of the aforementioned optical-waveguide chip and an optical fiber, and has viscosity, and which covered with a transparent filler optically.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to an optical waveguide circuit module with the high reliability which makes a basic component the optical waveguide used in an optical-communication field, and the optical fiber for I/O.

[0002]

[Description of the Prior Art] In addition to the conventional light source, the optical fiber, and the electric eye, optical waveguide circuits, such as an optical branching element, and an optical switch, an optical multi/demulitiplexer, are demanded with progress of an optical-communication field. As for this kind of optical waveguide circuit, it is common to constitute from a gestalt which connected the optical fiber for optical I/O to the optical-waveguide end face.

[0003] Drawing 2 shows an example of the conventional optical waveguide circuit module, and is (a) of drawing 2 . About a whole perspective diagram, it is (b) of this drawing. (a) The expanded sectional view of the direction of an A-A line view which can be set is shown, respectively. Here, a gestalt with being adopted [much] when there are few optical fibers which should be connected to the end side of an optical-waveguide chip as [about] 1-2 is shown.

[0004] It is the optical-waveguide chip of the 1x2 splitter composition of the quartz system which formed 1 on the silicon substrate in drawing 2 . It is compared through the index matching layer 5 so that the optical axis of the end face of the optical fibers 2, 3, and 4 for optical I/O may correspond with the end face. It is fixed to fiber

attaching part 7a near the end face of optical fibers 2, 3, and 4 by adhesives 6, and these whole is further contained by the real wearing package 7 which consists of metals, such as aluminum with which fiber attaching part 7a was united. In addition, the refractive index of the index matching agent which constitutes the index matching layer 5 is set as the value from which the reflection factor in a connection serves as the minimum in consideration of the refractive index of an optical fiber and an optical waveguide.

[0005] Thus, by the optical waveguide circuit module of a gestalt which connects a direct optical fiber to an optical-waveguide chip, in order to secure the mechanical strength and weatherability of a connection with the optical-waveguide chip itself and an optical fiber, it is contained by the real wearing package 7.

[0006] Moreover, drawing 3 shows other examples of the conventional optical waveguide circuit module, and (a) of drawing 3 is (b) of this drawing about a whole perspective diagram. (a) The expanded sectional view of the direction of a B-B line view which can be set is shown, respectively. Here, a gestalt with being adopted [much] when many optical fibers, for example, the 4 hearts, or 8 heart tape fiber should be comparatively connected to the end side of an optical-waveguide chip is shown.

[0007] This optical waveguide circuit module holds and fixes the optical-waveguide chip 8 of the quartz system formed on the silicon substrate at the case 9 for an optical-waveguide chip. Moreover, after holding and fixing the edge of 4 heart tape fibers 10 and 11 the optical fiber for optical I/O, and here at the cases 12 and 13 for optical fiber edges, respectively, So that the optical axis of 4 heart tape fibers 10 and 11 may be in agreement with the end face of the optical-waveguide chip 8 After preparing and carrying out alignment of the index matching layer 14 to both connection interface, the case 9 for an optical-waveguide chip and the cases 12 and 13 for optical fiber edges are welded and fixed by irradiating an YAG laser etc., and it is contained by the real wearing package 15 which these whole becomes from a metal further.

[0008] In addition, each cases 9, 12, and 13 are formed for each above-mentioned cases 9, 12, and 13 with metals, such as covar.

[0009]

[Problem(s) to be Solved by the Invention] However, by the former optical waveguide circuit module, each part material from which environmental temperature constitutes the optical waveguide circuit if change, for example, environmental temperature, goes up causes thermal expansion. Consequently, the length of the real wearing package 7

is also changed and the stress which is going to tear off the connection interface of an optical fiber and an optical waveguide works. If expansion of a package 7 is large, as shown in drawing 4 , the connection interface of an optical fiber and an optical waveguide will exfoliate, consequently foams, such as air, will be incorporated by the connection interface mainly from the exterior. The invasion of the foreign matter to such an interface becomes causes, such as dispersion, and brings about the remarkable increase in connection loss, and large degradation of return loss.

[0010] Moreover, as another problem, in the degree atmosphere of heat and high humidity, not only air but a steam etc. will be incorporated by the interface of this kind of optical waveguide circuit, and there was a problem that it had a remarkable bad influence on reliability.

[0011] Moreover, the optical-waveguide chip 8 and an optical fiber expand and contract, and when it holds under low temperature or hot environment, the interface of the optical-waveguide chip 8 and an optical fiber expands [by the mismatching of the coefficient of linear expansion of an optical-waveguide substrate and a case and the coefficient of linear expansion of an optical fiber and a case / for this reason] by the latter optical waveguide circuit module and contracts. As described above, when the case where covar was used as the quartz system light waveguide circuit formed on the silicon substrate as an optical waveguide and a case was taken for the example and an optical-waveguide chip with a length of 50mm is used since the coefficient of linear expansion of silicon and covar was 28x10-7 and 46x10-7, respectively, the change on the basis of 20 degrees C by the -40 degrees C - 80 degrees C temperature requirement is computed with **5.4 micrometers.

[0012] In such an optical waveguide circuit, by expansion and contraction of the interface which originates in the case of the former, and the mismatching of the coefficient of linear expansion of each part material similarly described above, and is produced, an index matching layer, an optical fiber, or an optical-waveguide interface exfoliates, consequently foams, steams, etc. of a connection interface, such as air, are incorporated mainly from the exterior, and the remarkable increase in connection loss and large degradation of return loss are brought about.

[0013] this invention is made in view of this situation -- having -- the purpose -- optical waveguide circuitry -- a member -- it is in offering the reliable optical waveguide circuit module which prevented property degradation resulting from the mismatching of the coefficient of linear expansion of a between

[0014]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, in

this invention, a transparent filler covered on the optical target which has an optical-waveguide chip and the optical fiber for optical I/O connected so that the optical axis may be in agreement with this optical-waveguide chip, and has a refractive index almost equivalent to the refractive index of the aforementioned index-matching layer for the circumference of the aforementioned connection interface at least in the optical waveguide circuit module which has an index-matching layer in the connection interface of the aforementioned optical-waveguide chip and an optical fiber, and has viscosity.

[0015]

[Function] An optical-waveguide chip and an optical fiber expand and contract, and when an optical waveguide circuit module is held under low temperature or hot environment, the interface of an optical-waveguide chip and an optical fiber expands [according to this invention / for this reason] and contracts by the mismatching of the coefficient of linear expansion of an optical-waveguide substrate and a case, and the coefficient of linear expansion of an optical fiber and a case. By this, the interval of the connection interface of an optical-waveguide chip and an optical fiber spreads, a gap is generated between an optical fiber end face and an optical-waveguide chip, and a filler invades in this gap. Since a filler has the refractive index of an index matching layer, and the almost same refractive index with an invasion in the gap of a filler, the property of the optical waveguide circuit in front of connection interfacial peeling and the same property are held.

[0016]

[Example] Drawing 1 shows the 1st example of the optical waveguide circuit module concerning this invention, and the same component as drawing 2 which shows the conventional example is expressed with the same sign among drawing. That is, the index matching layer [chip / optical-waveguide] which 1 becomes and an optical fiber and 5 become for example, from a silicone system jelly-like resin in 2, 3, and 4, the real wearing package which adhesives and 7 become from metals, such as ARUNIUMU, in 6, the fiber attaching part by which 7a was formed in the real wearing package 7 and one, and 21 are fillers with which it filled up in the real wearing package 7 for example, which consist of a silicone system grease-like resin. It has a refractive index with almost same index matching layer 5 and filler 21 which were used here.

[0017] In this example, optical fibers 2, 3, and 4 are being fixed to fiber attaching part 7a prepared in the package 7 by adhesives 6. If the environmental temperature of an optical waveguide circuit module is changed here, for example, environmental temperature rises, each part material which constitutes the optical waveguide circuit

will cause thermal expansion. Consequently, the length of a package 7 is also changed and the stress which is going to tear off the connection interface of optical fibers 2, 3, and 4 and the optical-waveguide chip 1 works. Thereby, the interval of the connection interface of an optical fiber and an optical-waveguide chip spreads, and a gap is generated between an optical fiber end face and an optical-waveguide chip.

[0018] Thus, if a gap is generated between an optical fiber end face and an optical-waveguide chip, as shown in drawing 5 , a filler 21 will invade in this gap. Since it has the refractive index of the silicone system jelly-like resin with which a filler 21 constitutes the index matching layer 5 with an invasion in the gap of a filler 21, and the almost same refractive index, the property of the optical waveguide circuit in front of connection interfacial peeling and the same property are held.

[0019] As mentioned above, according to this example, property degradation of the optical waveguide circuit resulting from the thermal expansion of a package 7 can be prevented. In addition, in this example, since the silicone system grease-like resin used as a filler 21 is excellent in moisture resistance, it can improve resistance to humidity.

[0020] drawing 6 is drawing showing the result which carried out the heat SASAIKURU examination by the -40 degrees C - 80 degrees C temperature requirement, in order to check the above-mentioned effect (a) of this drawing The test result to composition is shown conventionally which has not been filled up with the filler in a package 7, and it is (b) of this drawing. The test result to the composition of this example (drawing 1) filled up with the filler is shown. Moreover, the curve the curve shown as a solid line indicates a loss augend to be with an alternate long and short dash line shows temperature among drawing.

[0021] Although the big loss augend which originated in ablation of a connection interface at the elevated-temperature side was conventionally observed in composition so that drawing 6 might show, in the composition of this example, the loss change accompanying a thermo cycle was [less than 0.2dB and the total-temperature range] stable.

[0022] Moreover, drawing 7 is drawing showing the result which carried out the shelf test in 70 degrees C and 90% of environment, in order to evaluate the reliability over humidity. In the curve shown as a solid line, the curve which shows the test result to the composition of this example with a dashed line shows the test result to composition conventionally among drawing. Although the increase in loss was conventionally observed 300 hours after in composition as shown in drawing 7 , even if it passed 1000 hours in the case of this example, the increase in loss was 0.2dB or

less.

[0023] The optical waveguide circuit module in which temperature stability and resistance to humidity were excellent with this invention is realizable so that clearly from the above drawing 6 and the test result of drawing 7 .

[0024] In addition, although the grease-like resin which does not have an adhesion function as an index matching layer 5 was used for the connection interface of the optical-waveguide chip 1 and optical fibers 2, 3, and 4 in this example, it is also possible to instead use the transparent adhesives which were able to take index matching nature, for example, ultraviolet-rays hardening type adhesives. Also in this case, the above-mentioned effect and the same effect can be acquired by having the refractive index almost same as a filler 21 as the above-mentioned adhesives, and using a transparent grease-like resin or a jelly-like resin. Moreover, as adhesives used as an index matching layer 5, epoxy system adhesives, silicone system adhesives, acrylic adhesives, etc. are applicable, for example.

[0025] Drawing 8 shows the 2nd example of the optical waveguide circuit module concerning this invention, and the same component as drawing 3 which shows the conventional example is expressed with the same sign among drawing. That is, the index matching layer which 8 becomes from the olefin system jelly-like resin with which prepared 4 heart tape fiber, and 12 and 13 in the case for optical fiber edges, and the case for an optical-waveguide chip, and 10 and 11 prepared 14 for a quartz system optical-waveguide chip and 9 in the connection interface of the end face of the optical-waveguide chip 8 and the end face of 4 heart tape fibers 10 and 11, and 15 are a real wearing package and a filler with which 22 consists for example, of a silicone system In addition, the refractive index of the index matching layer 14 and a filler 22 is set as 1.46 like the refractive index of a quartz system optical waveguide.

[0026] The optical-waveguide chip 8 and an optical fiber expand and contract, and when this optical waveguide circuit module is held under low temperature or hot environment, the interface of the optical-waveguide chip 8 and an optical fiber expands [for this reason] and contracts by the mismatching of the coefficient of linear expansion of an optical-waveguide substrate and a case, and the coefficient of linear expansion of an optical fiber and a case. By this, the interval of the connection interface of an optical fiber and the optical-waveguide chip 8 spreads, a gap is generated between an optical fiber end face and the optical-waveguide chip 8, and a filler 22 invades in this gap. Since a filler 22 has the refractive index of the index matching layer 14, and the same refractive index with an invasion in the gap of a filler 22, the property of the optical waveguide circuit in front of connection interfacial

peeling and the same property are held like the case of the 1st example.

[0027] Therefore, an optical waveguide circuit module can prevent the loss accompanying [though left in an elevated temperature or low-temperature environment] expansion and contraction of each part material, and degradation of return loss. in order to verify the effect of the optical waveguide circuit module of this example, as a result of carrying out the thermo-cycle examination which it is in a -40 degrees C - 80 degrees C temperature requirement, the loss change accompanying a thermo cycle became clear [that less than 0.2dB and return loss are also as stable as -45dB or less]

[0028] Moreover, as a result of the shelf test under 70 degrees C and 90% of high-humidity/temperature environment, after 1000 hours passed after neglect, it was checked that 0.2dB or less and return loss are also -45dB or less, and the increase in loss is excellent also in moisture resistance.

[0029] In addition, although the case 9 for an optical-waveguide chip and the cases 12 and 13 for optical fiber edges were constituted from a metallic material like covar and welding fixation of both was carried out by YAG laser irradiation in connection between an optical waveguide and an optical fiber in this example, it is also possible to use the optical waveguide circuit fixed with adhesives with the same composition as drawing 8 .

[0030] What is necessary is to constitute the case 9 for an optical-waveguide chip and the cases 12 and 13 for optical fiber edges in drawing 8 from glass material like a Pyrex glass, and just to use the optical adhesives which also have an adhesion operation, for example, ultraviolet-rays hardening type epoxy system adhesives etc., in this case, as an index matching layer used for the connection interface of an optical waveguide and an optical fiber.

[0031] Also in such composition, the same effect can be acquired with having described above.

[0032] Drawing 9 shows the 3rd example of the optical waveguide circuit module concerning this invention. The point that the example of **** 3 differs from the 2nd example of the above is instead of being filled up with a filler 22 in [whole] a package 15 to have applied only near the connection interface of an optical waveguide and an optical fiber.

[0033] Thus, also in the composition which applies a filler 22 only near the connection interface, the effect of the 2nd above-mentioned example and the same effect can be acquired from a viewpoint of degradation prevention of an optical property.

[0034] Drawing 10 shows the 4th example of the optical waveguide circuit module

concerning this invention. The point that the example of **** 4 differs from the 3rd example of the above applies the filler 22 which consists of a grease-like resin which was able to take index matching nature near the connection interface of an optical waveguide and an optical fiber, and is to have filled up the portion of others in a package 15 with the filler 23 excellent in absorptivity further.

[0035] By making it such composition, since the filler 23 excellent in absorptivity was used from the first, excelling in an optical property can realize the optical waveguide circuit module excellent also in resistance to humidity.

[0036]

[Effect of the Invention] Though each composition member expands and contracts by environmental temperature change, and a gap is generated in the connection interface of an optical waveguide and an optical fiber according to this invention as explained above, since a filler trespasses upon this gap, degradation of the optical property of an optical waveguide circuit can be prevented.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing showing the 1st example of the optical waveguide circuit module of this invention

[Drawing 2] Drawing showing an example of the conventional optical waveguide circuit module

[Drawing 3] Drawing showing other examples of the conventional optical waveguide circuit module

[Drawing 4] Technical-problem explanatory drawing of the optical waveguide circuit module of drawing 2

[Drawing 5] Explanatory drawing of the optical waveguide circuit module of drawing 1 of operation

[Drawing 6] Drawing showing the test result of a thermo-cycle examination to temperature change of the optical waveguide circuit module of drawing 1

[Drawing 7] Drawing showing the test result of the resistance to humidity of the optical waveguide circuit module of drawing 1

[Drawing 8] Drawing showing the 2nd example of the optical waveguide circuit module of this invention

[Drawing 9] Drawing showing the 3rd example of the optical waveguide circuit module of this invention

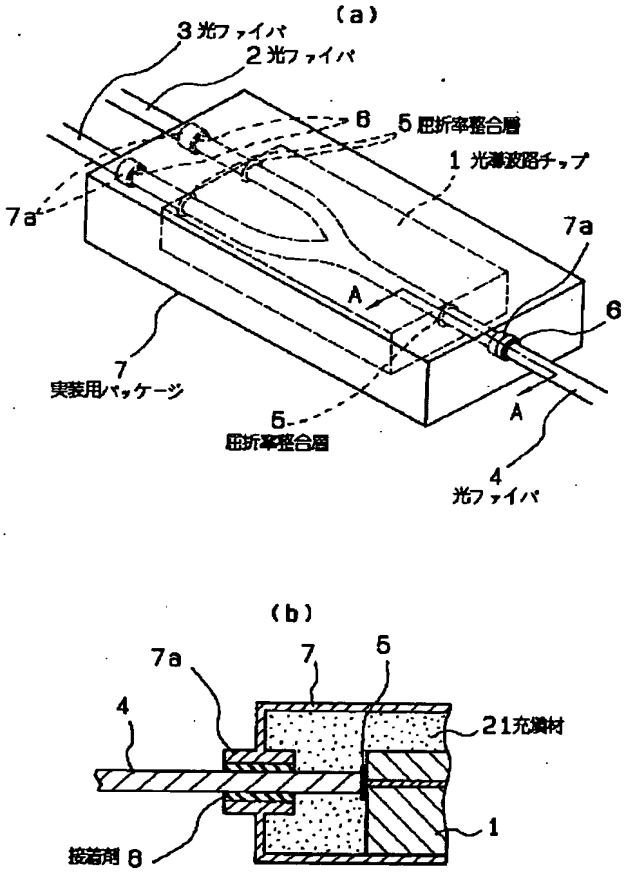
[Drawing 10] Drawing showing the 4th example of the optical waveguide circuit module of this invention

[Description of Notations]

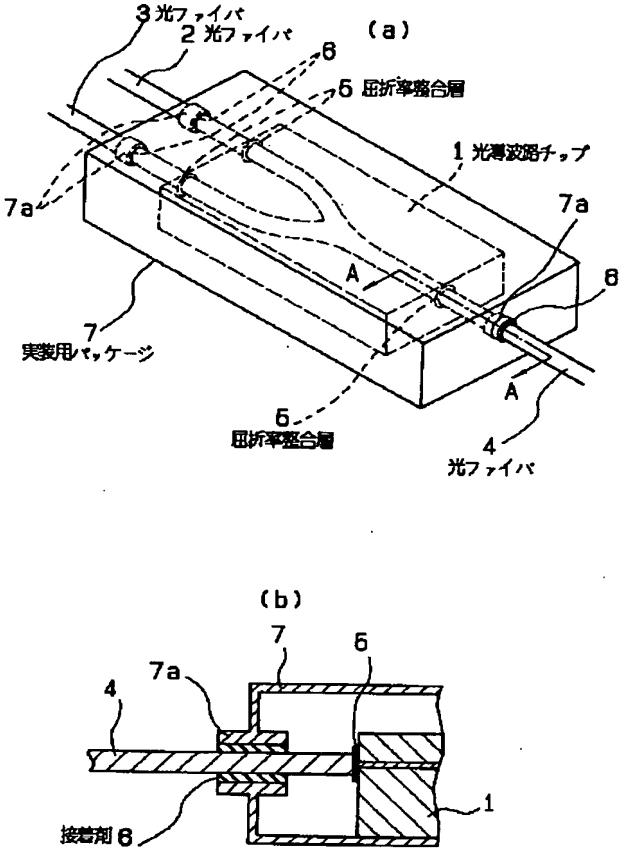
1 8 [-- 7 An index matching layer, 15 / -- The package for mounting, 21, 22, 23 / -- Filler.] -- An optical-waveguide chip, 2, 3, 4 -- 5 An optical fiber, 14

DRAWINGS

Drawing 1



Drawing 2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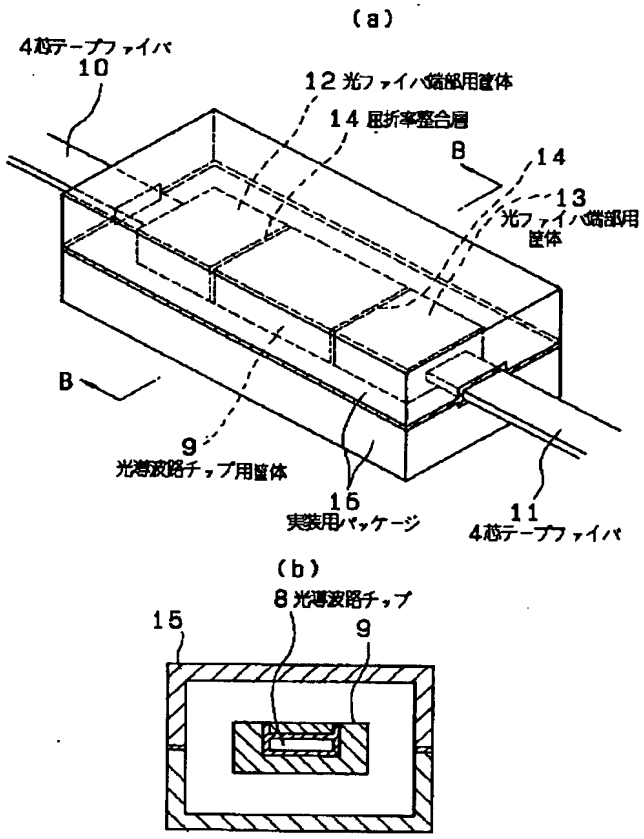
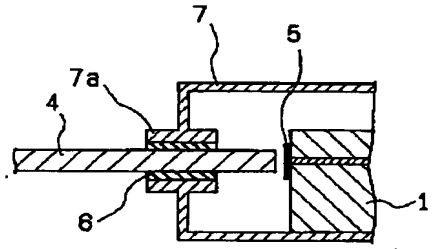
2 光ファイバ
(a)
6
5 屈折率整合層
1 光導波路チップ
7a
7a
A
6
7
実装用パッケージ
5
屈折率整合層
A
4
光ファイバ
(b)
7
6
7a
4
1
接着剤 8

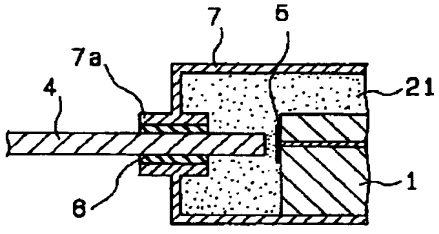
Drawing 3



Drawing 4



Drawing 5



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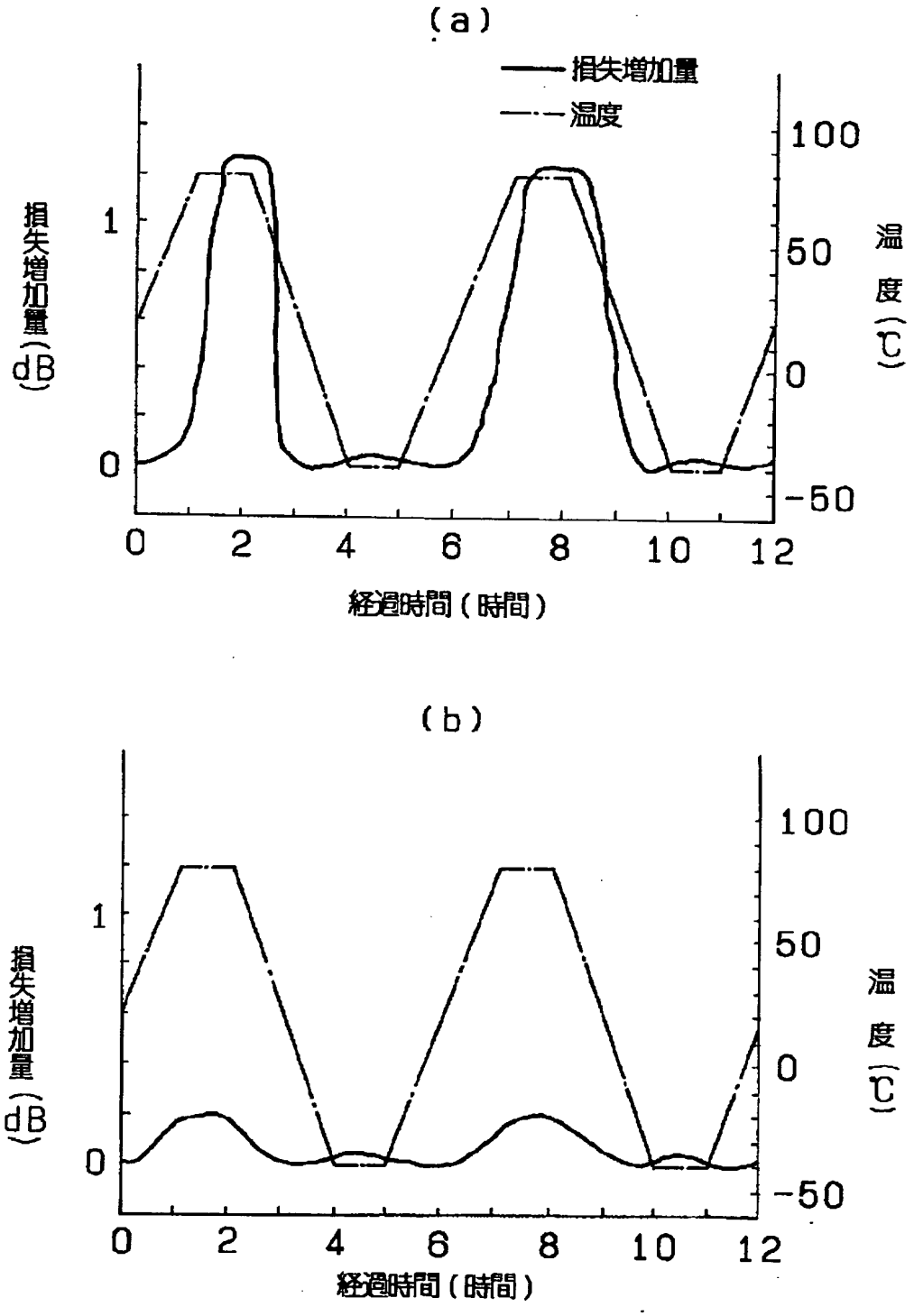
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6
8
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経過時間（時間）
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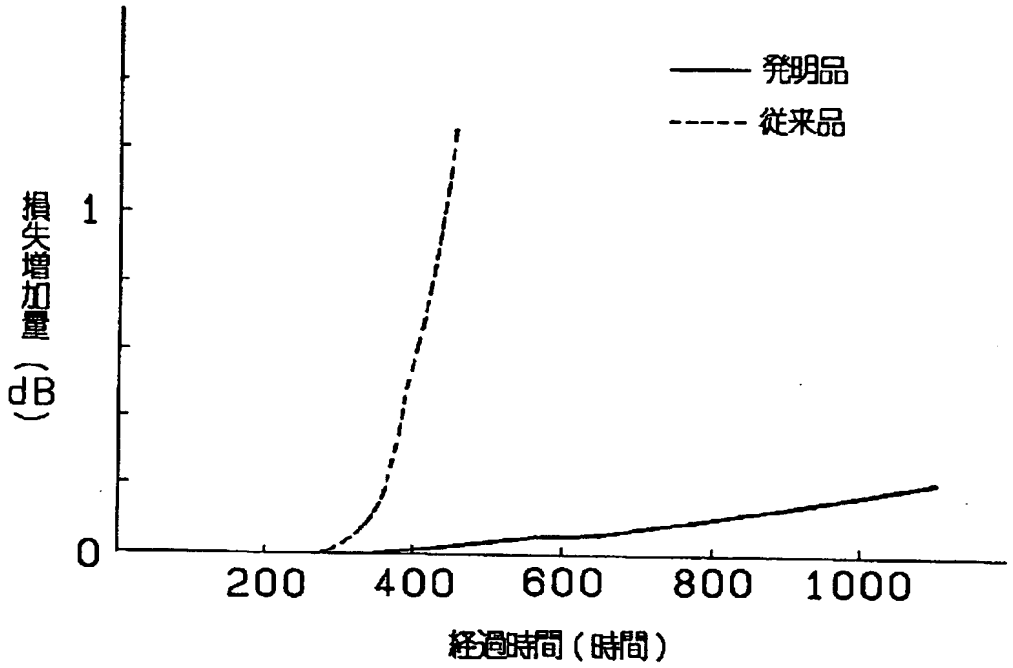
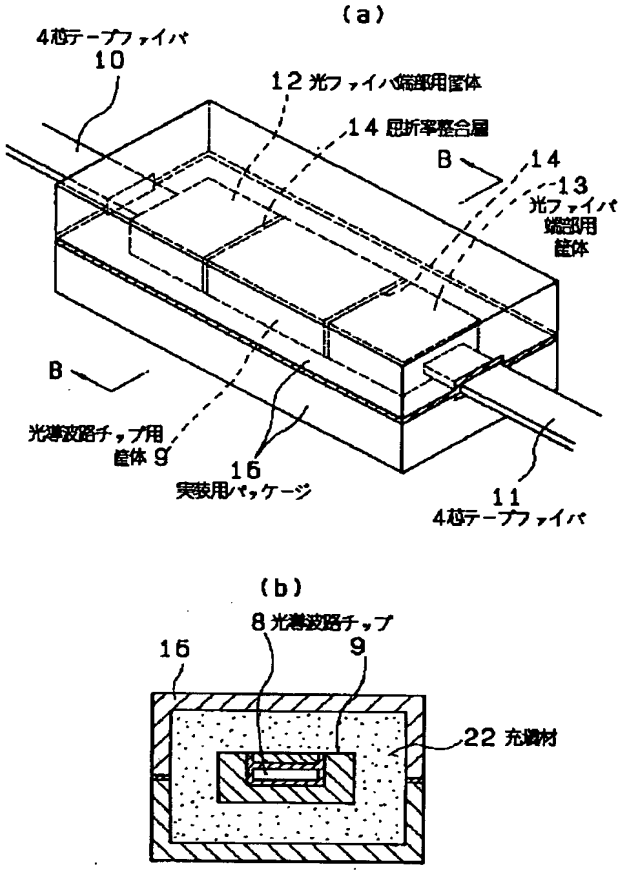
Drawing 7



Drawing 8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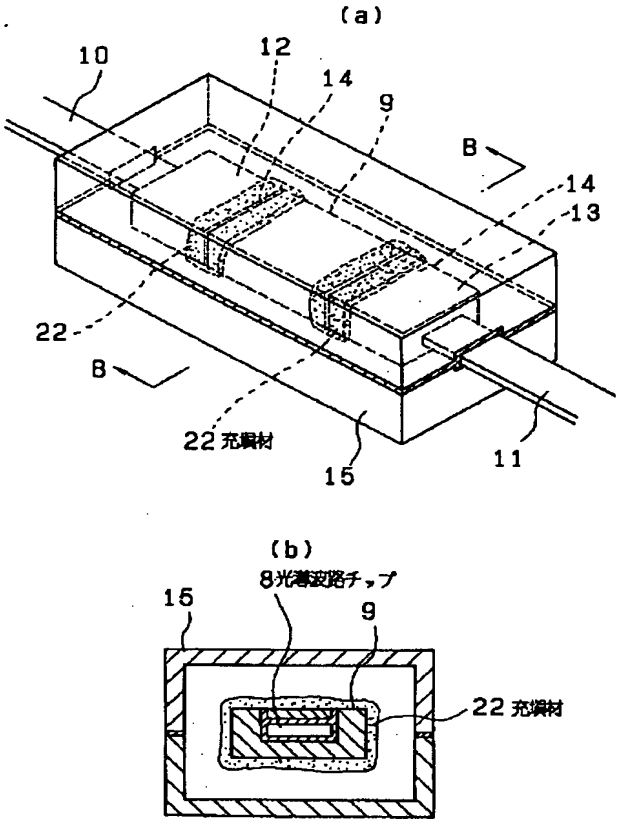
光ファイバ
端部用
筐体
B
光導波路チップ用
筐体 9
15
実装用パッケージ
11
4芯テープファイバ
(b)
8 光導波路チップ
15
9
22 充填材

Drawing 9



Drawing 10